Debuncher Momentum Cooling

The two big concerns with Debuncher momentum cooling are:

1) Get the beam momentum width (asymptotic momentum width) as small as possible.

2) Get the beam momentum width as small as possible *as fast as possible* (cooling rate).

Debuncher momentum cooling measurements done in the last several months have revealed the final (asymptotic) momentum width of the beam, the cooling rate, and the final center frequency are very sensitive to cooling system / RF alignment.

The ‘traditional’ method used to phase the momentum cooling (using a network analyzer) is a good ‘rough’ alignment, but has proven to be insufficiently accurate for operationally aligning multiple systems, and can in fact produce an alignment that is quite poor.

A new procedure using the beam itself is replacing the method of using a network analyzer for routine system alignments (cooling maintenance).

Debuncher Momentum Alignment
(The Old Way)

<u>How it was done:</u>

- There was no difference between a ‘rough’ system alignment and an operational alignment.
- Notch filter frequencies were set using a network analyzer.
- System phasing was done (run II) using Pbars, a long rep rate, and a network analyzer, one band at a time.
- Gap preserving RF (DRF2) was typically left on.

<u>Problems with this method:</u>

- System maintenance tuning required experts.
- Alignment of system notch filters using the NA required ‘eyeballing’ the filter phase. A ‘good’ alignment was then a matter of interpretation.
- By phasing each system independently using the network analyzer, final center frequencies for each band can differ by > 1Hz.
- Leaving DRF2 on can greatly affect the phasing measurements if the frequency it runs at differs from where the cooling is trying to put the beam. This leads to a wider final momentum width as the cooling fights the RF.

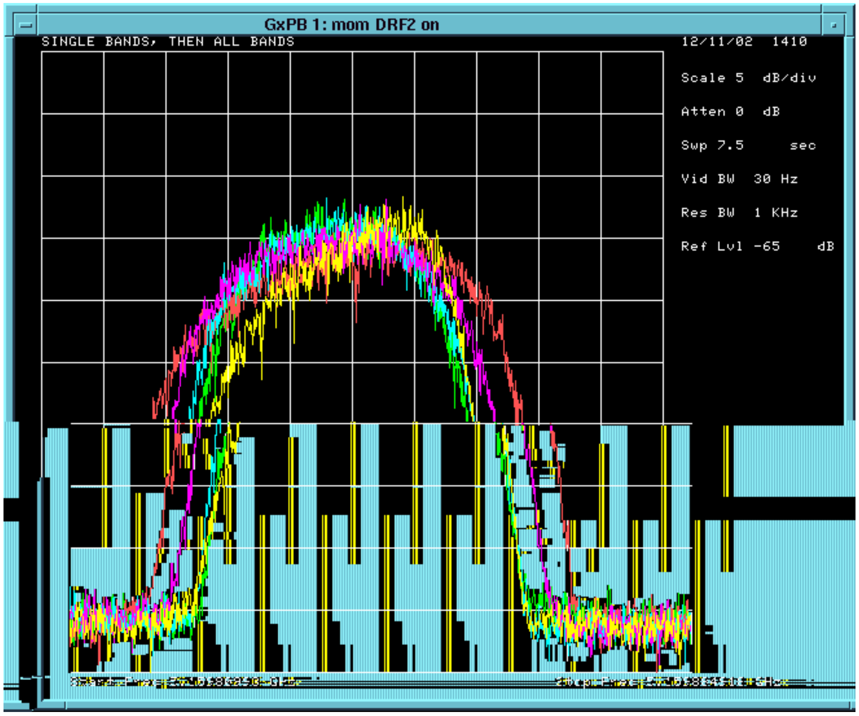

Fig 1: Initial measurements with DRF2 on.1 box ~ 0.8 Hz

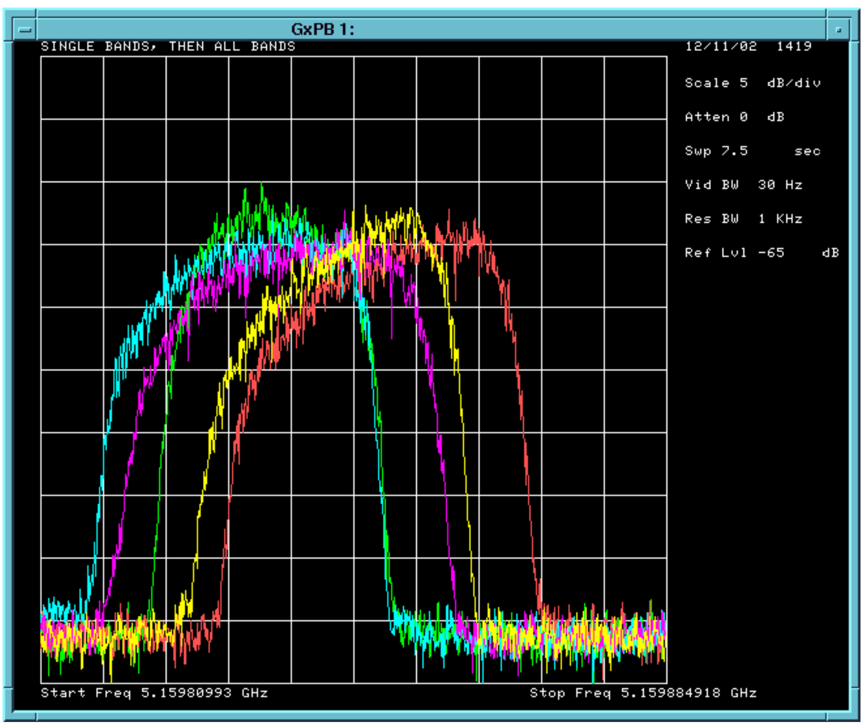

Fig 2: Initial measurements with DRF2 off. 1 box ~ 0.8 Hz. Note DRF2 'smears' the distribution into a near gaussian and hides the fact there is a bad alignment.

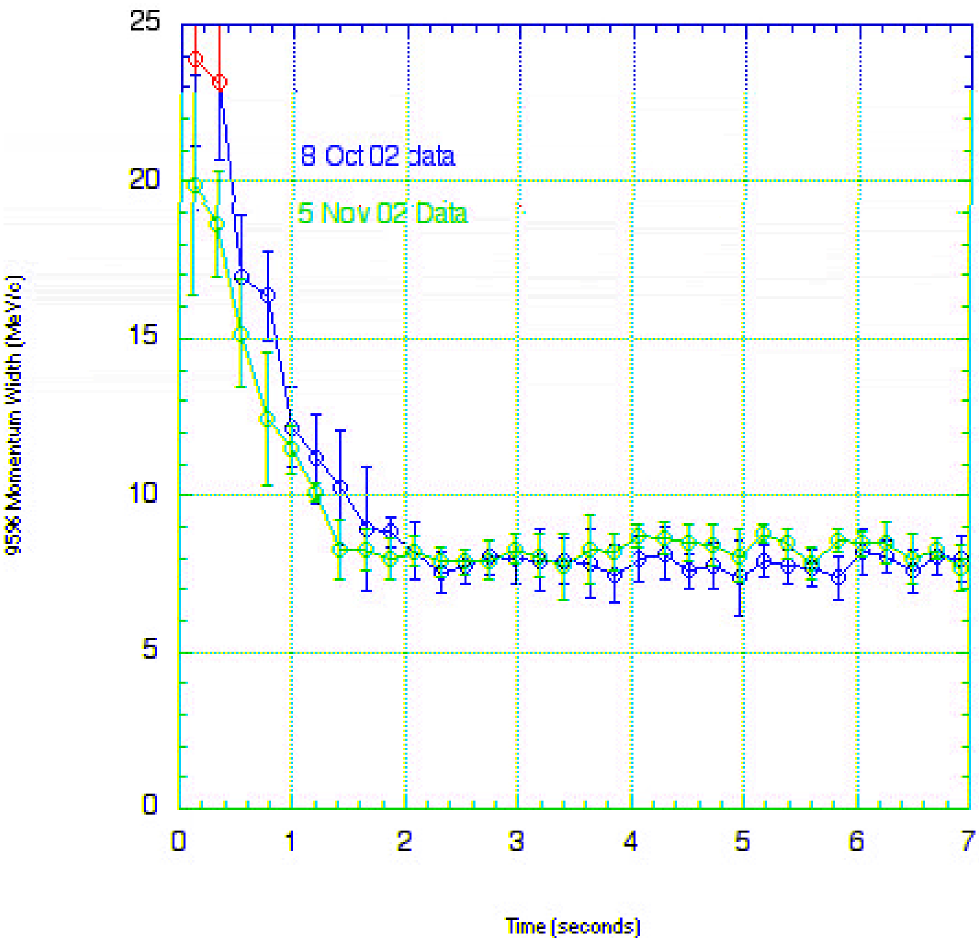

Fig 3: Cooling rate and asymptotic beam width. With the present cooling systems, we can just get to the limiting width in 1.5 sec. It is hoped that improved notch filters for bands 2 & 4 will lower the asymptotic beam width.

Debuncher Momentum Alignment
(The New Way)

Phasing using the beam:

- To prevent the RF from dragging the beam away from where the cooling wants to put it, DRF2 is turned off for the duration of the alignment procedure.
- A long repetition rate (~30s) is used to allow each momentum band by itself enough time to completely cool the beam to its asymptotic limit and final center frequency.
- With the other 3 systems off, the momentum band 1 notch filter is moved to center the beam at the desired frequency (typically 590035 Hz).
- The system trunk trombone is adjusted to maximize the rate at which the TWT power drops (a faster drop in power means the momentum width is dropping faster).
- Now using band one as a benchmark, the other three bands are adjusted in the same manner to agree with band 1, while still looking at the band 1 schottky.
- When the individual systems are aligned and on, DRF2 is turned back on. If the RF drags the beam away from the desired frequency, the flattop frequency of MIRF is adjusted using I6 to align them.

This procedure gets us to within ~½ Hz of our desired center frequency when all four bands are turned back on and a nearly perfect band-to-band alignment.

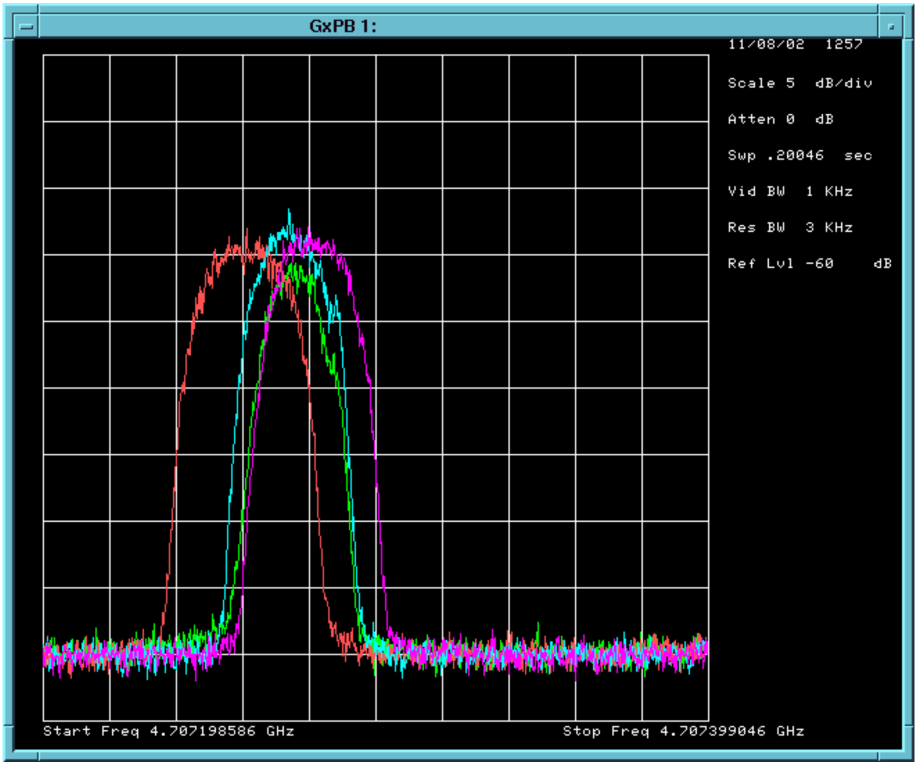

Fig 4: Initial measurements of each band with DRF2 off

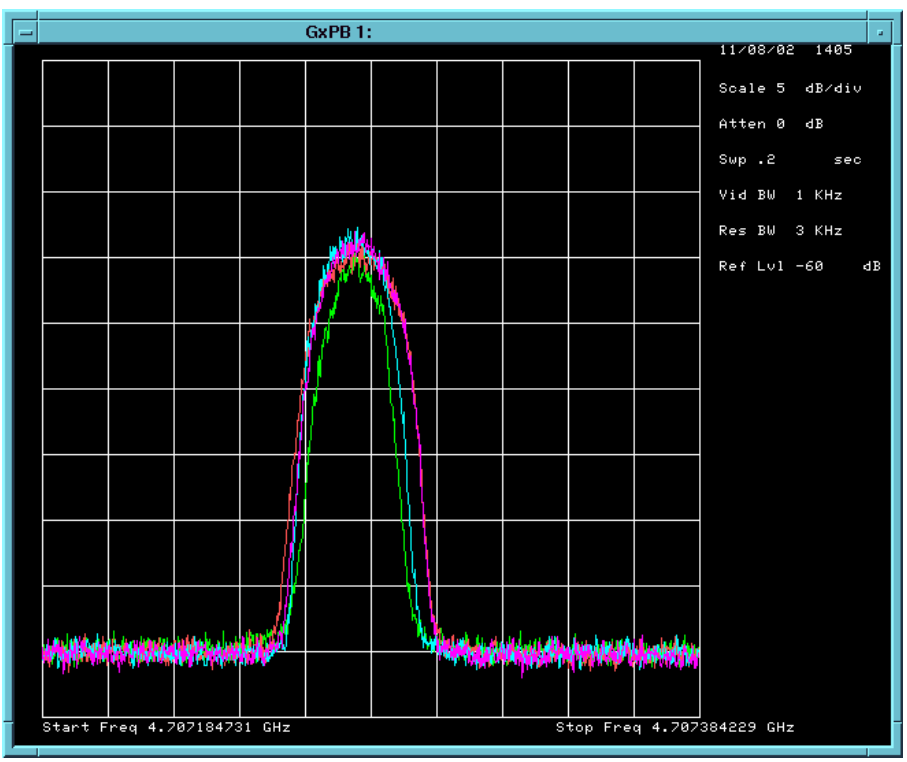

Fig 5: Each individual band after system notch filters aligned.

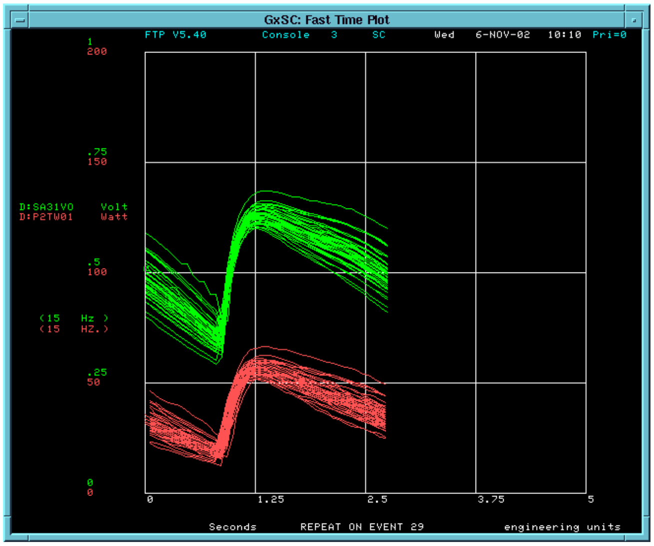

Fig 6: Adjusting trunk delay to maximize cooling rate (D:PxTM1). The delay that gets the steepest slope on the red trace is the best trunk setting.

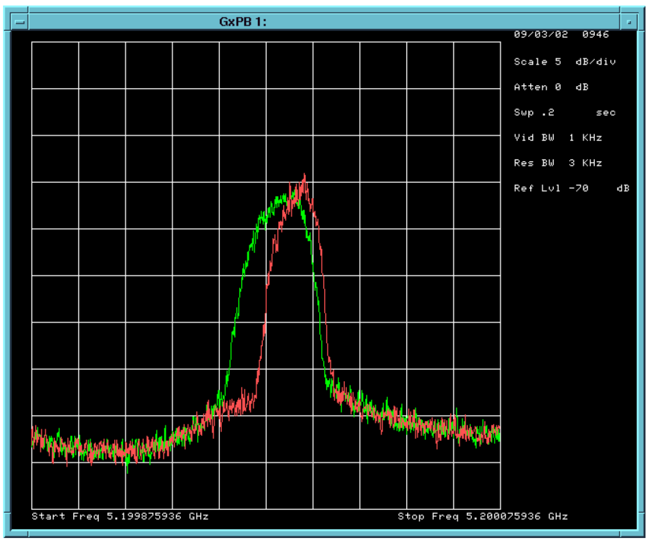

Fig 7: In green, all four momentum bands together with DRF2 on. The red trace is with DRF2 off. To line traces up, a change in the MIRF flattop frequency in necessary.

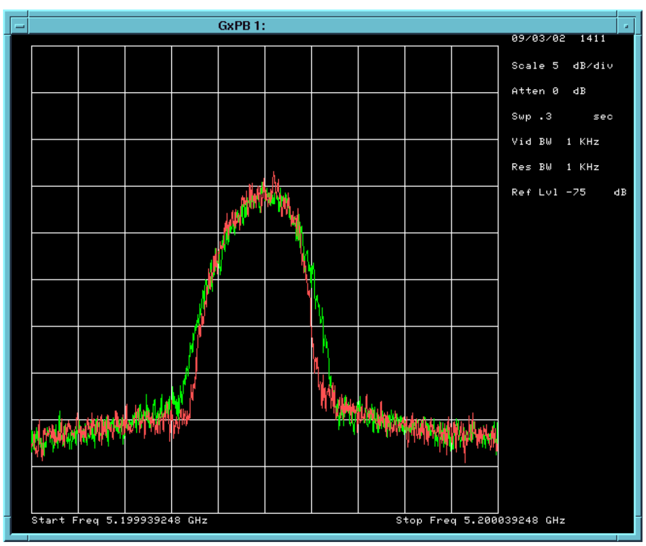

Fig 8: After aligning MIRF and momentum cooling. Note the span of this plot is smaller than in fig 6 to improve resolution.

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Future:

- Our main concern now turns to the final momentum width of the beam.

- We can get to the present asymptotic limit in 1.5 seconds, but due to dispersion in our notch filters, we cannot get the beam thinner than about 3.7 Hz. This is about 9.25 MeV (1Hz = 2.5 MeV). The principal problems are in momentum bands 2 & 4; equalizers are being designed to fix this problem.

- A smaller momentum width means less ARF1 bucket area is needed to move the injected beam over to the stacktail; this in turn allows us to run less stacktail power, which in turn reduces core heating.

- Put another way, for the same ARF1 voltage and stacktail gain, we can run a faster reprate.

- We are starting to look at ways of automatically maintaining notch filter alignment (and why they drift in the first place).